Guidelines for the Prevention of Infection Following Combat-related Injuries

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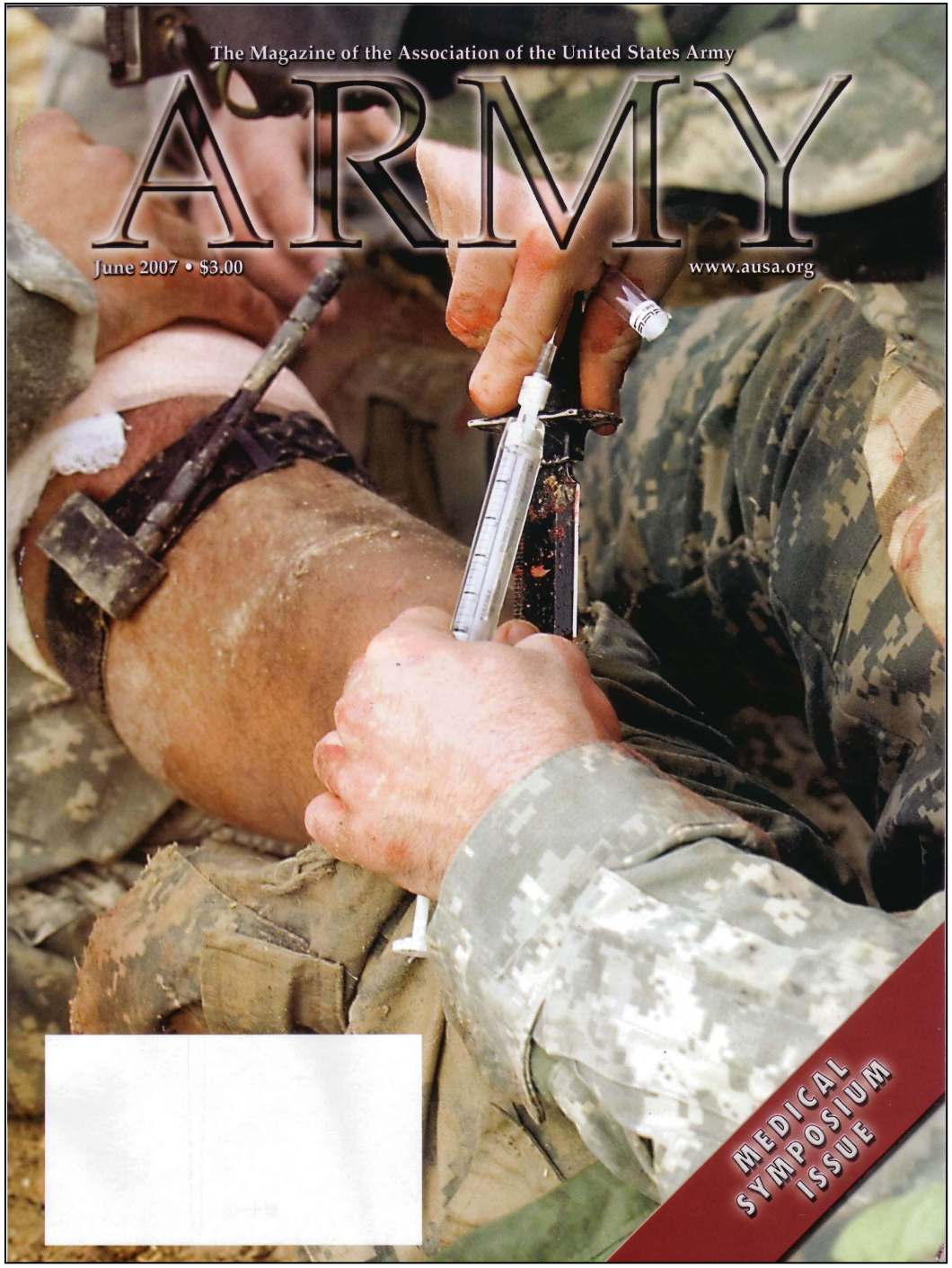
Force Health Protection- 10 August 2007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MEDICAL SYMPOSIUM ISSUE

Combat-related Infections Guidelines

- Sponsored by the US Army Office of the Surgeon General

- Conference directors
  - COL Duane R. Hospenthal
  - COL John B. Holcomb
  - MAJ Clinton K. Murray

Guidelines
Conference Goals

- Develop clinical practice guidelines to prevent infections associated with traumatic combat injuries

Guidelines
Conference Goals

- Provide overall guidance to US military health care providers, both deployed and in permanent medical treatment facilities, based on the echelon at which care is provided

Guidelines
Conference Goals

- Accompanying evidence based manuscripts providing guidance by anatomical site of wounding
  - Extremity
  - Central Nervous System
  - Head and Neck
  - Thorax and Abdomen
  - Burn

Guidelines
Participants

- US Army specialty consultants (surgical and infectious disease)
- Participation by US Air Force, US Navy, and civilian trauma experts
- Representatives from the infection control and preventive medicine community

Guidelines
Participants

- LTC RC Andersen
- JH Calhoun, MD
- COL LC Cancio
- MAJ KK Chung
- Maj NG Conger
- HK Crouch
- Maj LC D'Avignon
- COL JR Ficke
- LTC RG Hale
- COL DK Hayes
- EF Hirsch, MD
- MAJ JR Hsu
- Col DH Jenkins
- LCDR JJ Keeling
- COL LE Moores
- CDR KN Petersen
- JR Saffle, MD
- JS Solomkin, MD
- CAPT SA Tasker
- AB Valadka, MD
- LTC AR Wiesen
- COL GW Wortmann

Combat-related Infections
Overview

- Historical review
- Current OIF/OEF epidemiology
- Guideline development
- Guidelines

Greeks
Homer's Iliad and Odyssey

- Therapy
  - Mechanical debridement- remove arrow
  - Rinse wound with warm water or wine
  - Cover wound with bandage soaked in wine
  - Apply analgesic
  - Apply styptic herbal drugs

Achilles bandages the arm of Patroclus

Pikoulis 2004

Napoleonic Wars
Amputations

- Larrey performed 200 battlefield amputations in a single day without using anesthesi
- One every 7.2 minutes
  - Hip- 15 seconds
  - Shoulder- 11 seconds
- 80% died

Hell 1999

Civil War
Federal Troops

- No antiseptics used on wounds
- Operated in pus stained white coats
- Wounds explored with unwashed fingers

Bollet 2004

Civil War
Knowledge

- Laudable pus
- Malignant pus
- Overall wound fatality 14.5%

Bollet 2004

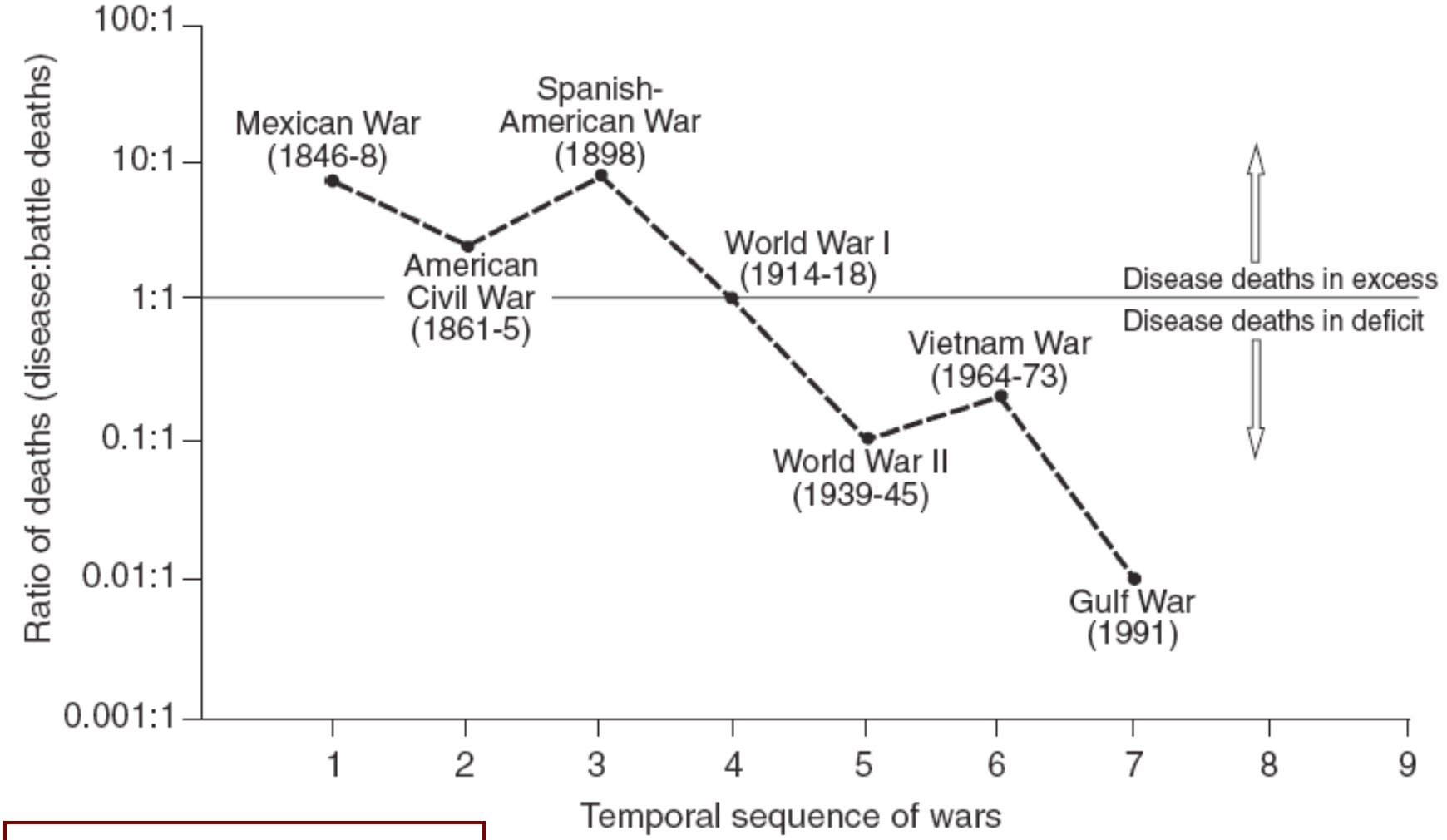
History of Modern ID
Era of Microbiology

- 1862- germ theory (Pasteur)
- 1867- antiseptic surgery (Lister)
- 1881- growth of bacteria on solid media (Koch)
- 1884- gram stain (Gram)

Lister's microscope

http://users.stlcc.edu/kkiser/History.page.html

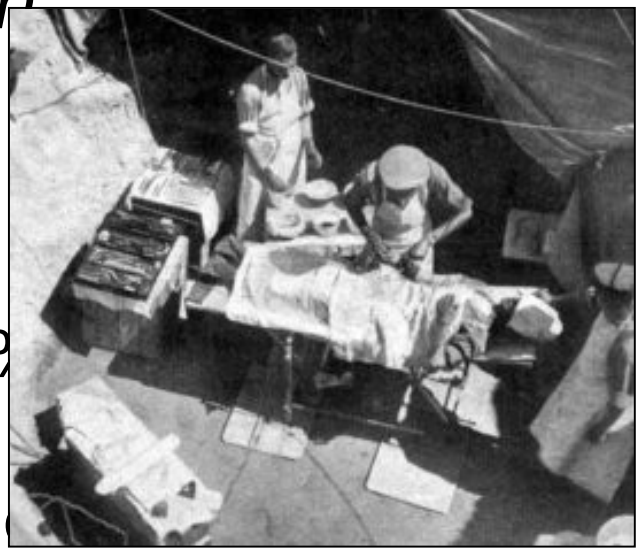
Disease to Battle Deaths
Transition



Smallman-Raynor 2004

World War I
Modern Surgical Management

- Appropriate surgical management likely led to the disappearance of *Clostridium* associated gas gangrene
  - WWI- 5% incidence with 28% mortality
  - WWII- 1.5% incidence with 15% mortality
  - Korea- 0.08% incidence with n mortality



WWI OR

Heisterkamp 1969

World War I
Timing of Procedure

- Patients treated
  - Within 1 hour- 10% mortality
  - After 8 hours- 75% mortality

Hardaway
2004

History of Modern ID
Era of Antibiotics

- 1936- Sulfanilamide
- 1942/3- Penicillin

Forrest 1982; Kiehn 1989

World War II
Pearl Harbor

- November of 1941, Dr. John J. Moorhead, chief surgeon for the New York Subway System, came to Honolulu
- Described the techniques for treatment of large soft tissue wounds

Moorhead 1942; Hardaway 1999

World War II
Pearl Harbor

- Only a week later- Pearl Harbor was attacked

World War II
Pearl Harbor

- Procedures used
  - Careful debridement
  - Irrigation of wounds
  - Sprinkled in sulfanilamide powder (which was in salt shakers)
  - Left the wounds open and performed a delayed primary closure after three days

World War II
Pearl Harbor

- The immediate reaction “sulfanilamide powder is wonderful”
- The Surgeon General recommended that small packets of sulfanilamide pow included in the first a every soldier

World War II
Lessons Learned

- Sulfanilamide powder was dumped in as a lump rather than being sprinkled in so that each grain was separate
- No debride

World War II
Penicillin and Group A Strep

- Eventually systemic penicillin was used during World War II
- It eradicated infections with *S. pyogenes*

Lyons 1946, Pulaski 1953

World War II
Flap and External fixation

- Applying pedicle graft
- Using Stadler external fixation apparatus

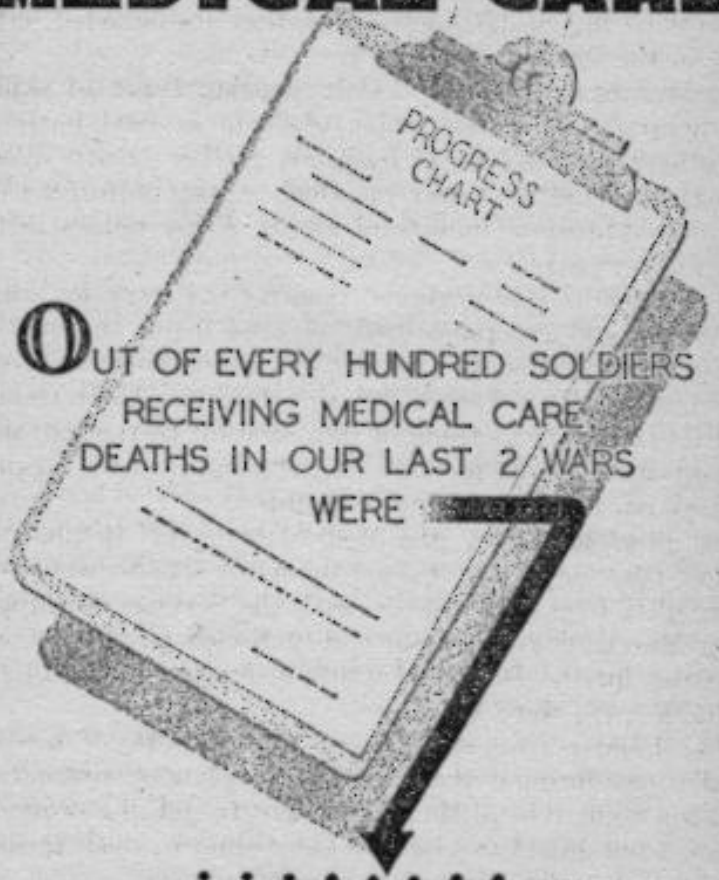
Kiehn 1989

World War II
Nosocomial Transmission

- 5% of wounds were secondarily infected at the time of admission
- 50% were infected after 1 week of hospitalization
- 70-80% were infected after that

Altemeir 1944

MEDICAL CARE



OUT OF EVERY HUNDRED SOLDIERS
RECEIVING MEDICAL CARE
DEATHS IN OUR LAST 2 WARS
WERE

Korean War
Antibiotic Era

- Instituted use of penicillin and streptomycin as wound prophylaxis
- Increasingly resistant bacteria were reported from infected war wounds 3-5 days aft

Kovaric 1968; Wannamaker 1958

Vietnam War
Antibiotic Era

- During Vietnam broader spectrum of antimicrobial agents were implemented
- Increasingly resistant bacteria were reported in war wounds

Kovaric
1968

Vietnam War
Causes of Death

- Vietnam war- surgical patients 93% (1,162)
  - 43% (494) head injuries
  - 24% (278) hemorrhagic shock
  - **12% (136) septic sh**

Arnold 1978

Vietnam War
Infections

- 4% incidence of wound infections (not including infections after air evacuation)
  - 80% underwent debridement
  - 70% receive

Jacob 1989

Vietnam War

Wound cultures 1967-1968-Japan

Bacteria	% of total positive initial culture (1,153 cultures)
S. aureus	29
P. aeruginosa	18
E. coli	17
Polymicrobial	12
Proteus species	6

Matsumoto 1969

Vietnam War
Brooke General Hospital

Bacteria from tissue biopsy	%
P. aeruginosa	47
S. aureus	20
Proteus species	13
Klebsiella Enterobacter group	12
Streptococcus pyogenes	5

Heggers
1969

Vietnam War
Burn Casualties

- Stabilized in Japan- 106th General Hospital
- Established December 1965

FIGURE 23.—General Heaton observed patient care at an Army hospital in South Vietnam during a visit in November 1967. (Walter Reed Army Institute of Research photograph.)

J Trauma 1970

Operation Just Cause
Wound Infections

- 37 open fractures- 9 infected
  - *CNS*
  - *P. aeruginosa*
- Surgery in the US vs Panama was associated with more infections

Jacob 1992

Gulf War I
Wound Infections

- No well described study assessing infections associated with trauma

Somalia
Wound Infections

- 11 of 58 wounded in action infected
- Bacteria identified
  - Polymicrobial
  - *Pseudomonas*

Mabry
2000

Combat-related Infections
Overview

- Historical review
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- Guideline development
- Guidelines


OPTIQUE
Endure Medical, Inc.


القوات الخاصة

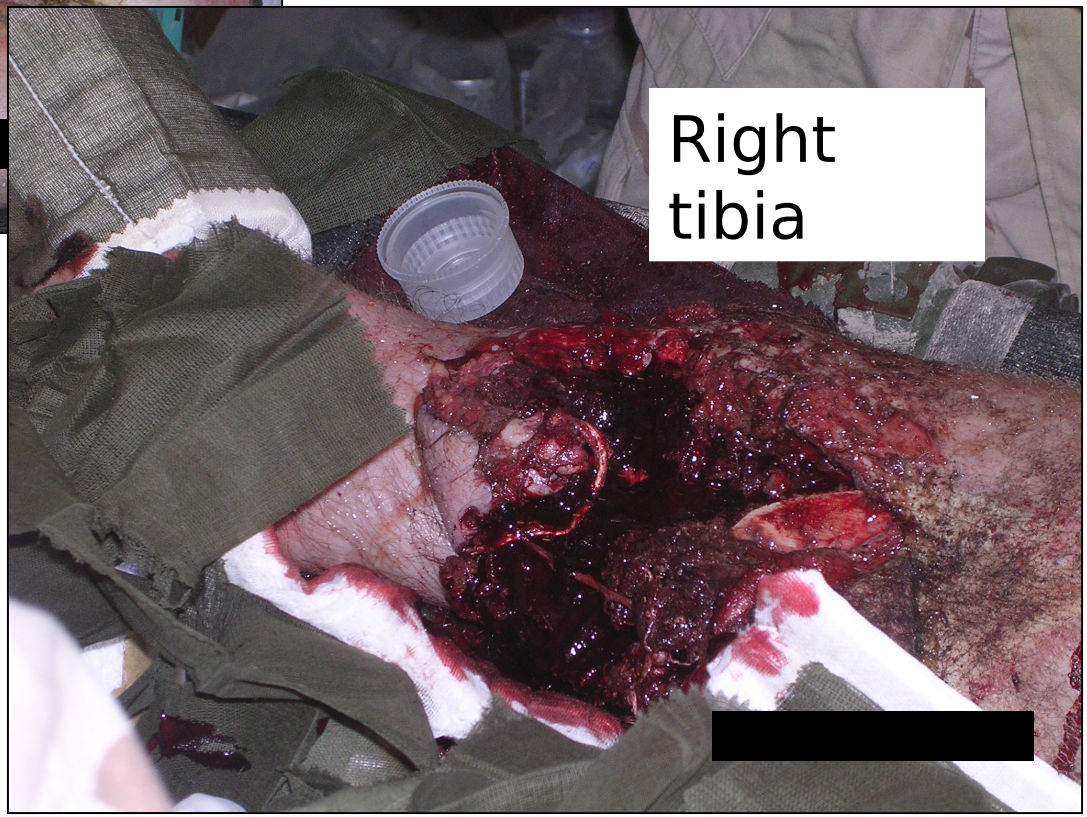

571st

Combat-related Infections

Percentage of Injury

	Head & Neck	Thorax	Abdomen	Limbs
WWI	17	4	2	70
WWII	4	8	4	75
Korean War	17	7	7	74
Vietnam War	14	7	5	74
Gulf War	11	8	7	56
Somalia	20	8	5	65

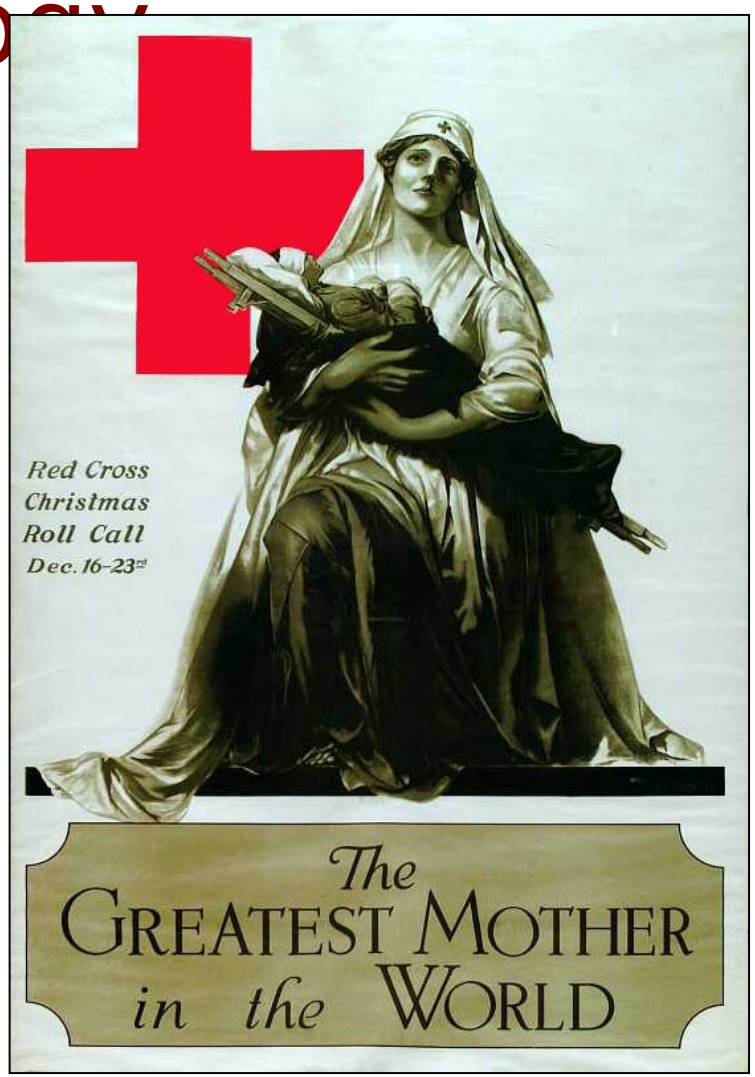
Emergency War Surgery 2004


Right
tibia

Combat-related Infections

Bacteriology

- Time of injury
- Echelon III
- Echelon V



Wound Bacteriology
Iraq

- Cultures of US and coalition soldiers
- 31st CSH Baghdad, Iraq
- 49 casualties- 61 wounds

Murray 2006

Wound Bacteriology

Pathogens

Gram-positive		Gram-negative	
CNS	32	*Pseudomonas stutzeri*	1
S. aureus	4 *	*C. meningosepticum*	1
Micrococcus sp.	1	*E. coli*	1

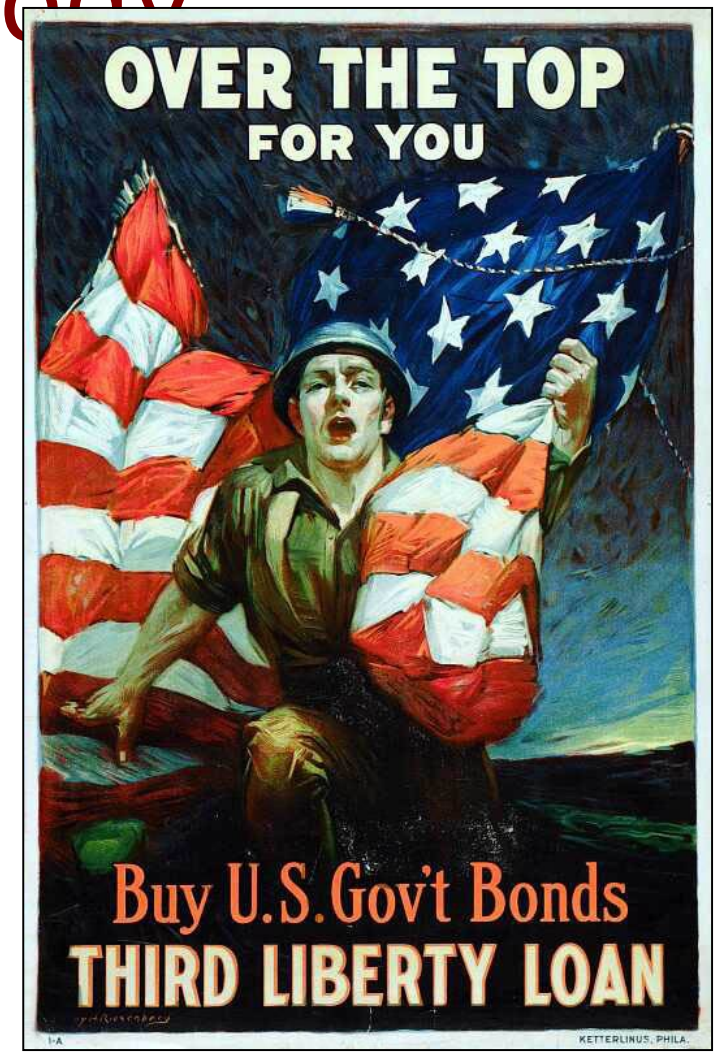
Murray 2006

*2- methicillin resistant *S. aureus*

Combat-related Infections

Bacteriology

- Time of injury
- Echelon III
- Echelon V



What Do We Know- In Theater

CSH- Infections 03-04

Yun 2006

What Do We Know- In Theater

Abx Susceptibility- Jan-June 06

Bacteria (#)	1st	2nd	3rd
Acinetobacter (159)	Meropenem (46%)	Amp/sulbac (45%)	Amikacin (41%)
E. coli (93)	Meropenem (100%)	Amikacin (90%)	Pip/tazo (73%)
Klebsiella (66)	Meropenem (95%)	Amikacin (89%)	Gatifloxacin (80%)
Pseudomonas	Amikacin (95%)	Gatifloxacin (77%)	Pip/tazo (70%)

Provided by Mike Landrum

***US and nonUS personnel**

Wound Bacteriology
USNS Comfort

- March-May 2003
- 300 admissions- 211 trauma patients- 56 infected
  - 85% Iraqi
  - Mean time from injury to admission was 4.2 days

Petersen 2007

Wound Bacteriology
USNS Comfort

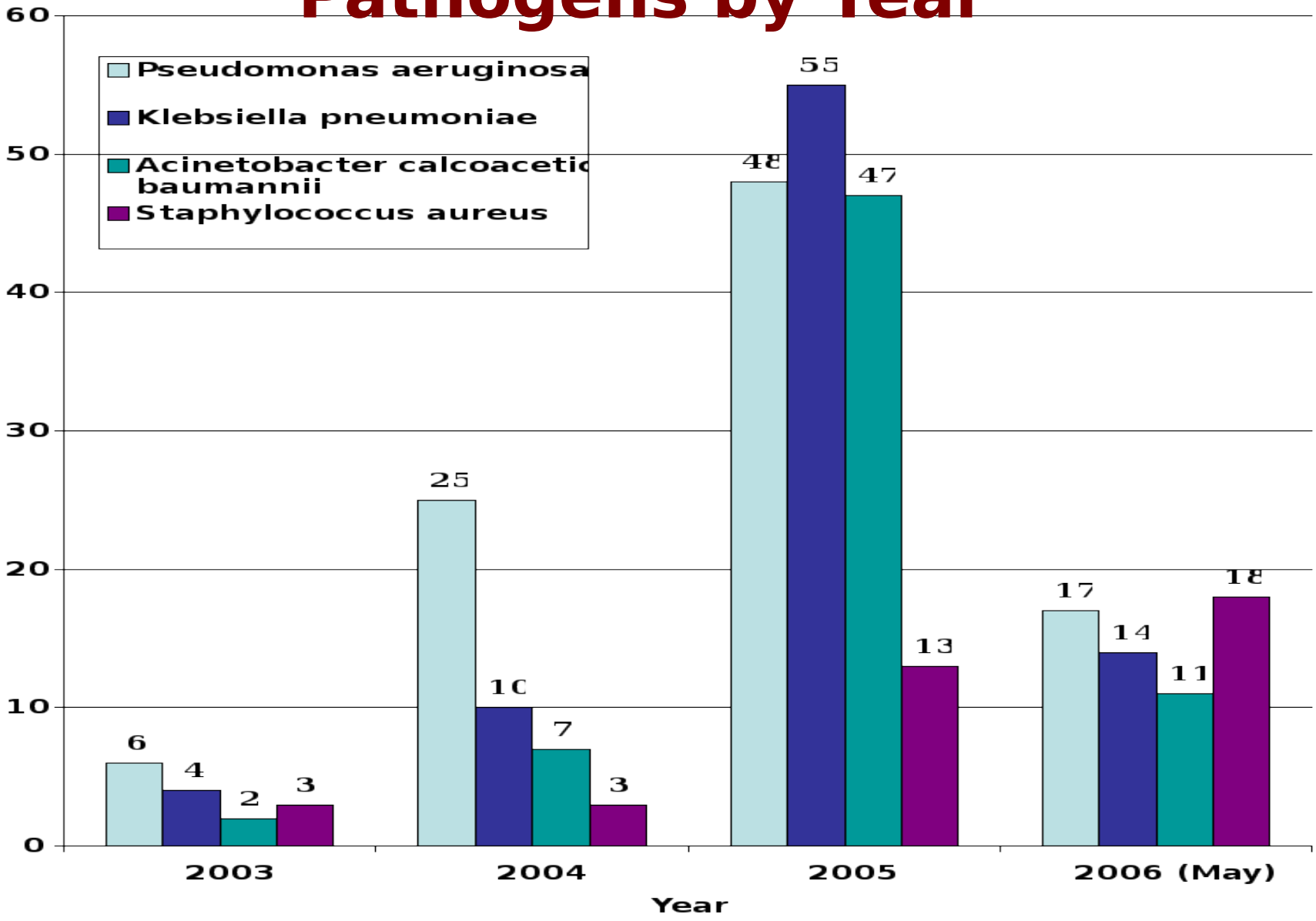
- 47 of 56 had wound infections
  - 47% were polymicrobial
- 21 of 56 had blood infection
  - 34% were polymicrobial
- Pathogens
  - *Acinetobacter*- 33%
  - *E. coli*- 14%
  - *Pseudomonas*- 14%

Combat-related Infections

Bacteriology

- Time of injury
- Echelon III
- Echelon V

BAMC Burn ICU- Most Common Pathogens by Year



Combat-Related Infections

Orthopedic Patients

- March 2003-July 2006- osteomyelitis
  - 110 patients with ns
    - 99 lower extremity
    - 48 upper extremit
    - 2 axial infections

Yun, IDSA 2007 meeting submission

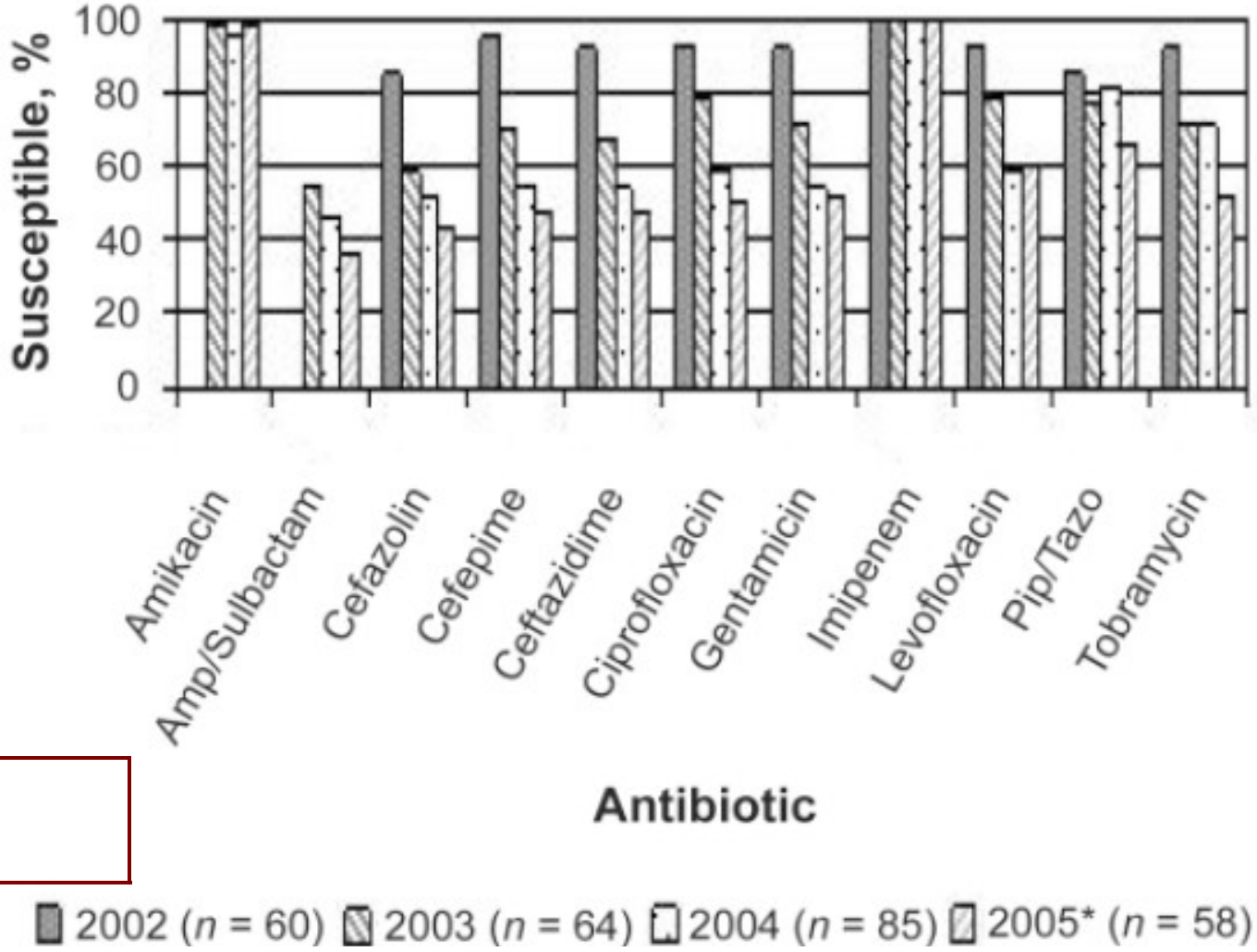
Combat-Related Infections

Orthopedic Patients

- Original versus recurrent/relapse
  - *Acinetobacter* spp.- 71% vs 5%
  - *K. pneumoniae*- 24% vs 5%
  - *P. aeruginosa*- 26% vs 5%
  - *S. aureus*- 15% vs 50%
    - MSSA- 6% vs 22%
    - MRSA- 10% vs 28%

Resistant Bacteria

Klebsiella pneumoniae



Aronson 2006

Combat-related Infections

Transmission

- Colonized
- Inoculated at time of injury
- Nosocomial

Resistant Bacteria
Etiology

- Acinetobacter and other MDR pathogens
  - Hospital-acquired infections in Turkey
  - Ventilator-associated pneu
    Lebanon
  - ICUs in Kuwait
  - Bacteremia in Israel

Garzoni 2005, Oncul 2002, Kanafani 2003, Rotimi 1998; Jerassy 2006

Resistant Bacteria
Etiology

- Germany
  - 100 a/e patients from Iraq without prior hospital exposu had axilla and groin swabs
  - 0% *Acinetobacter* detected
- Iraq
  - 101 healthy soldiers in Iraq had hands, feet, and head swabs
  - 0% *Acinetobacter* detected

Scott 2007, Griffith 2007

Resistant Bacteria
Etiology

- Inoculated from the environment- no casualties had gram negative MDR bacteria

Resistant Bacteria

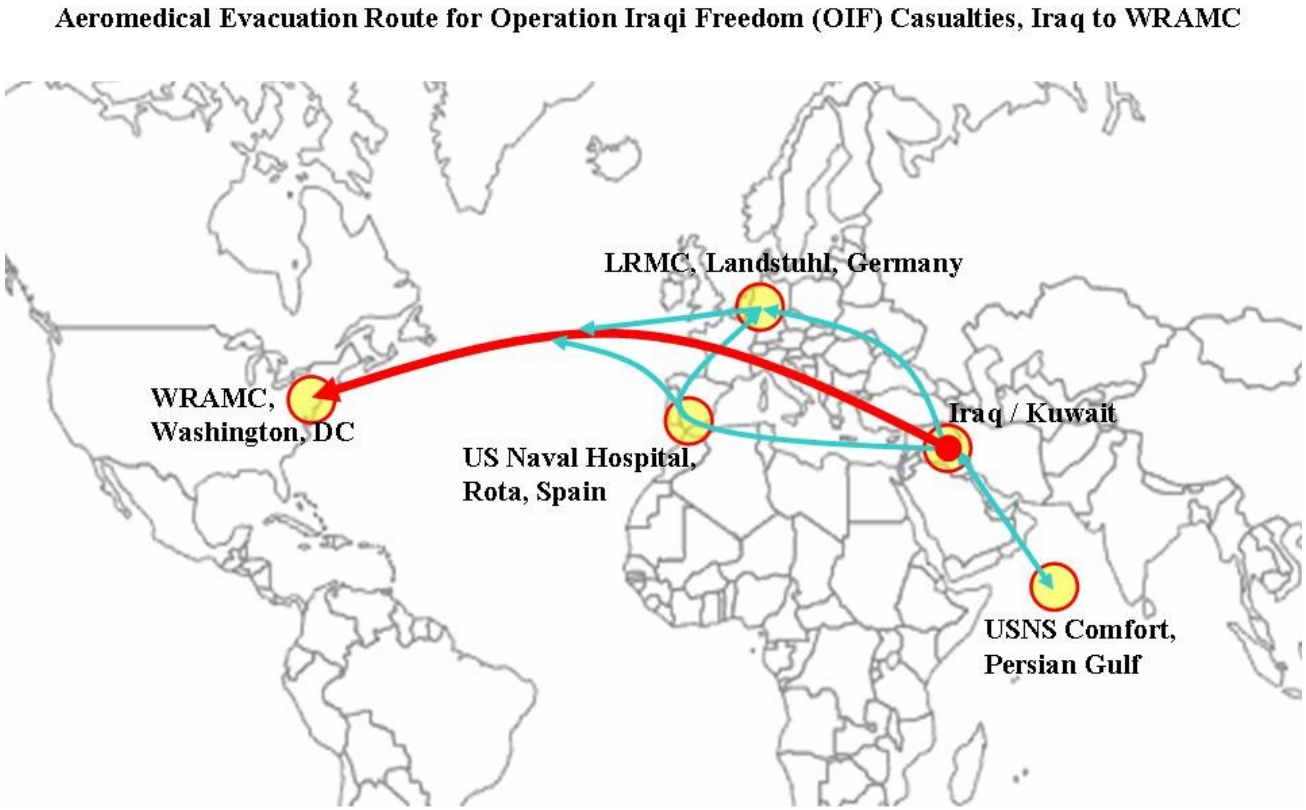
Etiology

- Nosocomial transmission

Pictures provided by Stuart Roop

Resistant Bacteria

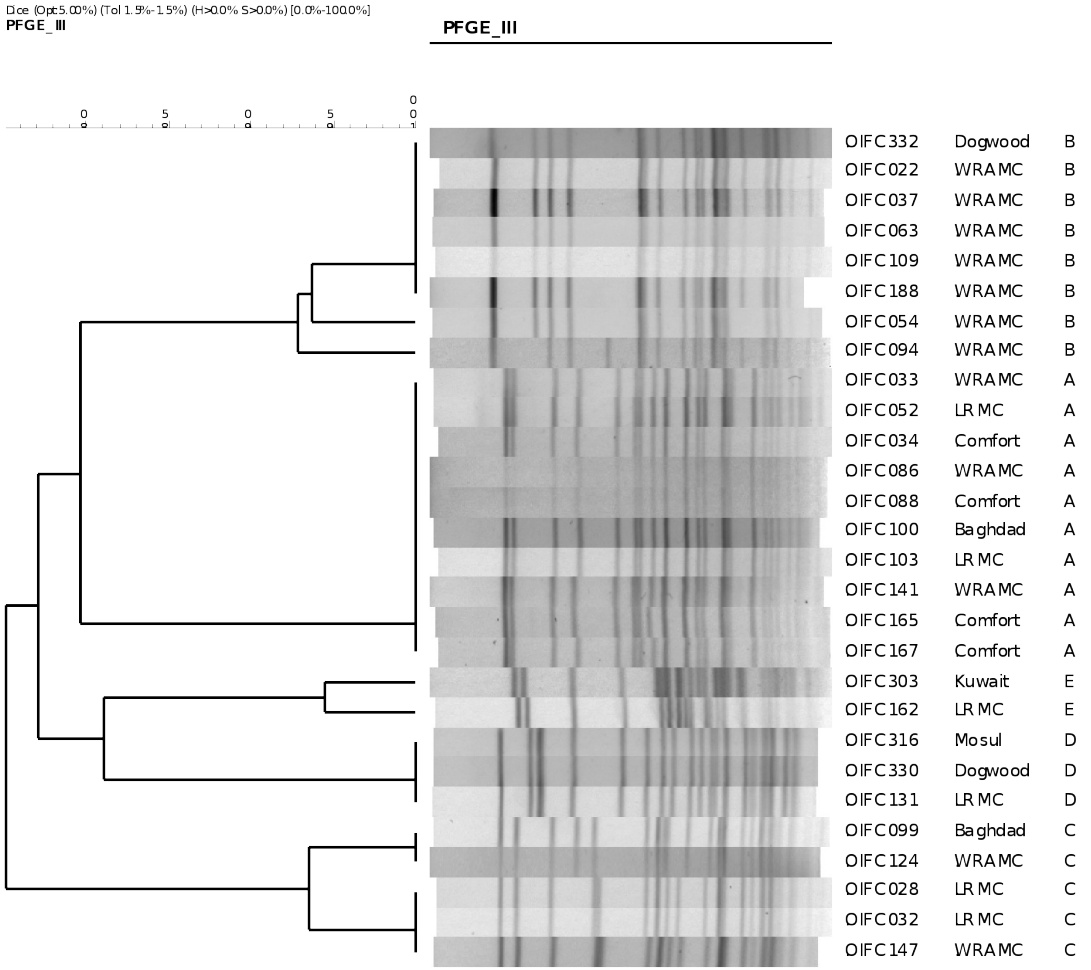
Etiology



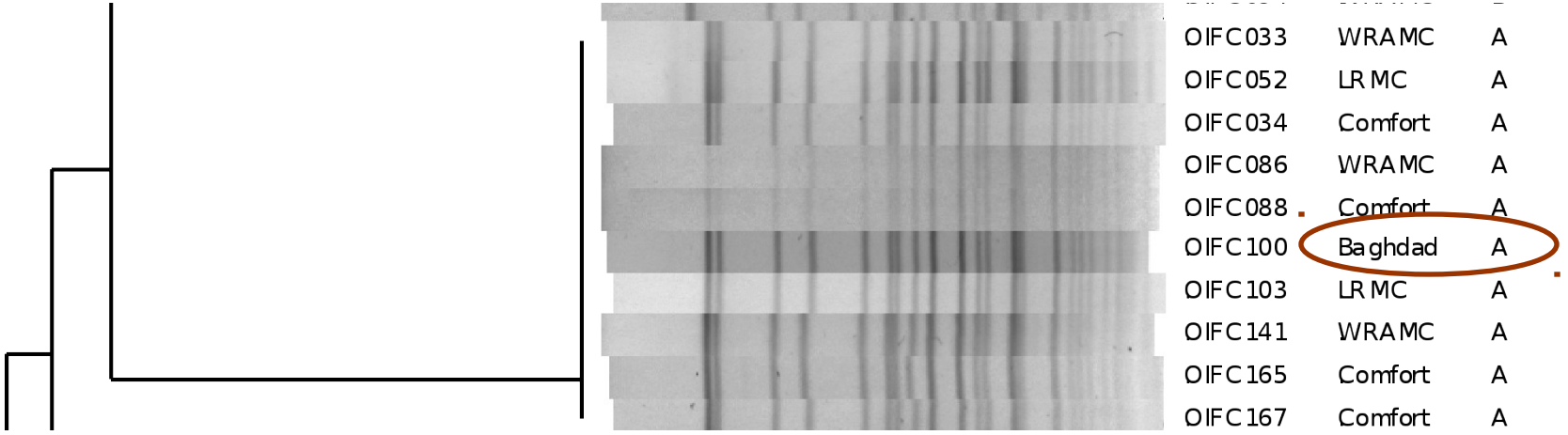
Scott
2007

Resistant Bacteria
Etiology

- PFGE strains
  - 66 different strains among 170 clinical isolates
  - 25 different strains among 34 environmental isolates



Resistant Bacteria
Etiology



- 43 patients- 2 Baghdad, 18 Comfort, 6 LRMC, 19 WRAMC

Resistant Bacteria
Etiology

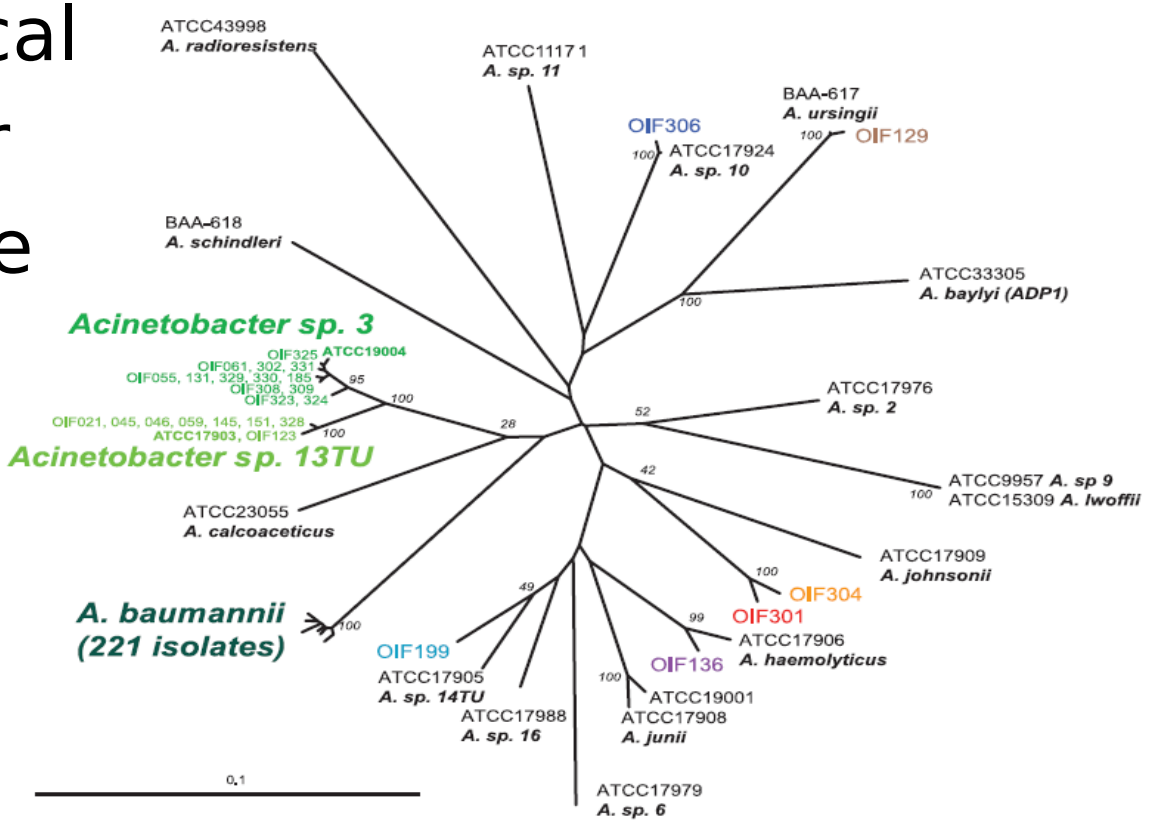
- DNA profiles from UK and US isolates iden

United Kingdom and U.S. isolates[d]	
UK 1	T strain
UK 2	T strain
UK 3	T strain
UK 4	T strain
UK 5	T strain
US 7	T strain
US 9	T strain
US 13	T strain
US 1	T strain
UK 14	OXA-23 clone 2
US 12	OXA-23 clone 2
UK 23	H1AC-2[b]
UK 10	H1AC-2[b]
UK 11	H3AC-1[b]
US 8	USAC-3[b]
Other United Kingdom isolates	
UK 6	W strain
UK 8	W strain
UK 22	V strain
UK 19	SE clone
UK 20	OXA-23 clone 1

Turton 2006

Resistant Bacteria
Etiology

- Relatedness to European isolates
  - 14% identical
  - 37% similar
  - 49% diverse



Ecker 2006

Combat-related Infections
Overview

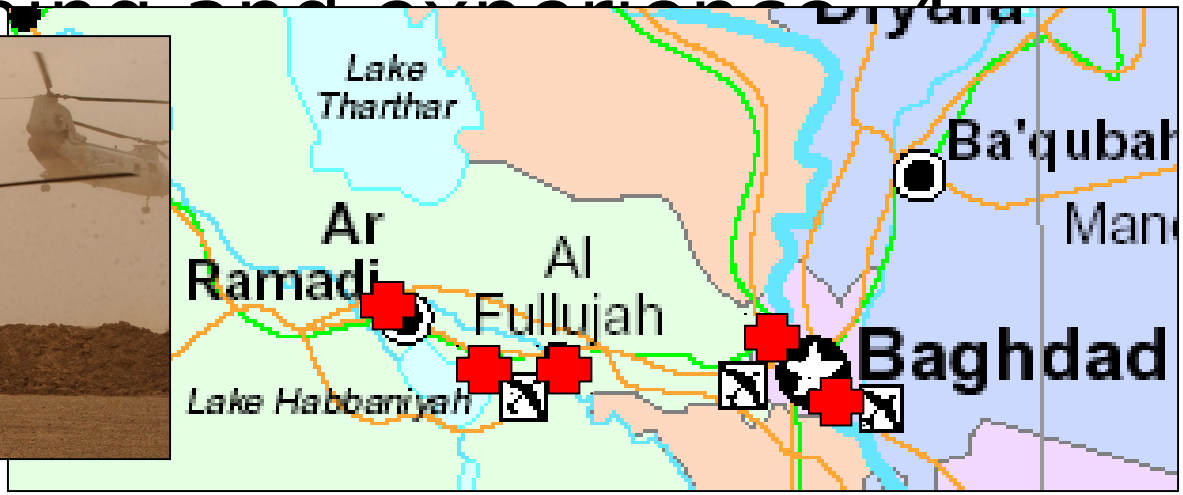
- Historical review
- Current OIF/OEF epidemiology
- Guideline development
- Guidelines

Combat-related Infections
Working Group

- 11-12 June 2007
  - Triservice with civilians
  - Substantial deployment experience

Combat-related Infections
Assumptions

- Rapid evacuation- injury to US (~7 days)
- Medical facilities- injury to US (~4 sites)
- Varying training and experience



Combat-related Infections
Assumptions

- Some personnel not evacuated

Combat-related Infections
Assumptions

- Multidrug resistant pathogens are infecting war wounded
- No standard prevention guidelines currently exist

Combat-related Infections

Scope- Not Addressed

- Blood transfusion
- Hyperglycemia
- Hypothermia
- Oxygenation

Combat-related Infections
Scope- Not Addressed

- Treatment of nosocomial infections
  - Requires in theater microbiology
  - Requires continually updated antibiogram
  - Rapid de-escalation of antibiotics to monotherap
  - Minimize peri-operation antibiotics

Combat-related Infections
Target Patient Population

- US, coalition forces- primarily young healthy men without co-morbidities
- Civilian personnel in theater- older with co-morbidities

Combat-related Infections
Target Audience

- Health care providers rendering care to combat-related injuries
- Focused on echelon I-III with echelon IV/V recommendations in supporting manuscripts

Combat-related Infections
Scientific Review

- Experts reviewed literature prior to arrival with emphasis on military studies
- Group discussed all findings/ recommendations as a group and then by disseminated of findings/recommendations

Combat-Related Infections
Evidence Based Recommendations

- Strength of Recommendations
  - A- Good evidence to support a recommendation for use
  - B- Moderate evidence to support a recommendation for use
  - C- Poor evidence to support a recommendation for or against use
  - D- Moderate evidence to support recommendation against use
  - E- Good evidence to support a recommendation against use

Combat-Related Infections
Evidence Based Recommendations

- Quality of Evidence
  - I. Evidence from at least one properly randomized controlled trial
  - II. Evidence from at least one well-designed clinical trail without randomization or from cohort or case-controlled studies
  - III. Expert opinion

Combat-related Infections
Overview

- Historical review
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Combat-related Infections
Care at Point of Injury

- Evacuation with surgical evaluation within 6 hours

Combat-related Infections
Care at Point of Injury

- Wounds covered with sterile bandage
- Underlying bony structures stabilized
- If evacuation longer than 3 hours use antibiotics recommended by TCCC
  - Moxifloxacin 400 mg po X 1 OR
  - Ertapenem 1 gm IV/IM X 1

Combat-related Infections
Care without Surgeon- BAS

- Stabilization and evacuation within 6 hours of injury
- Wound irrigation with removal of gross contamination
  - 1-3 L potable water without additives under low pressure

Combat-related Infections
Care without Surgeon- BAS

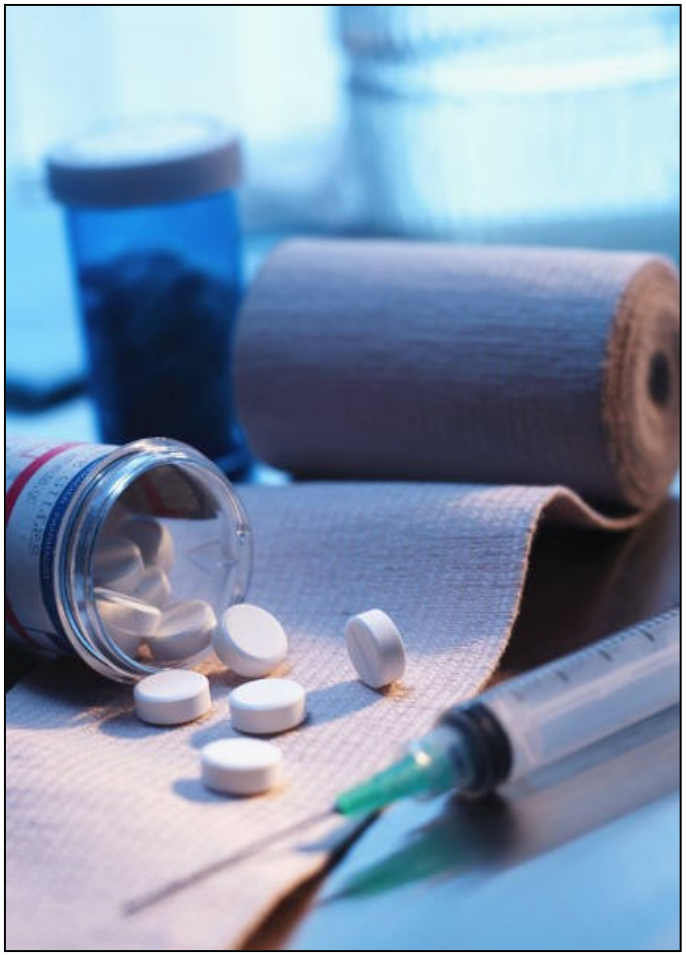
- Bandage wounds
- Stabilize underlying bony struc

Combat-related Infections
Care without Surgeon- BAS

- Antibiotics
  - Skin, soft tissue, open fractures, exposed bone or open joints
    - Cefazolin 1 gm IV
    - Clindamycin 900 mg IV
    - No enhanced gram negative coverage

Combat-related Infections
Care without Surgeon- BAS

- Antibiotics
  - Abdomen
    - Cefoxitin 1 gm IV
    - Piperacillin-tazobactam- 4.5 gm IV



Combat-related Infections
Care without Surgeon- BAS

- Tetanus toxoid
- Tetanus immunoglobulin
  - No prior immunization and presentation greater than 24 hours
  - Finish tetanus toxoid series

Combat-related Infections
Care without Surgeon- IIa

- Same therapy as BAS
- Retained metal fragment- 1 dose cefazolin
  - Soft tissue injuries only (no fractures, no major vascular involvement and no break of pleura or peritoneum)
  - Wound entry/exit less than 2 cm in maximum dimension
  - Wound not frankly infected
  - Exclusion of mine wounds

Combat-related Infections
Care with Surgeon- IIb/III

- Surgical evaluation within 6 hours
- Not absolutely necessary for surgical procedure within 6 hours

Combat-related Infections

Care with Surgeon- IIb/III

- No pre/post procedure culture
- Only culture if suspicion of infection

Combat-related Infections

Care with Surgeon- IIb/III

- Aggressive debridement of foreign bodies and necrotic tissue
- Burns debrided within 24 hours
- Delayed removal of foreign body
  - Eye
  - Spine
  - Brain*

* Foreign body may be retained

Combat-related Infections
Care with Surgeon- IIb/III

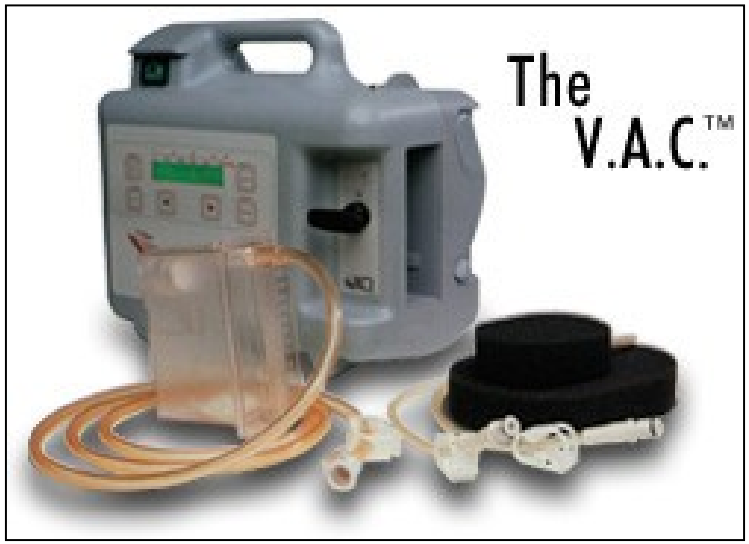
- Irrigation
  - Bone- Type I fracture- 3L, Type II- 6 L, Type III- 9L
  - Other sites- until contamination removed
  - Fluid- NS or sterile wate water ok)
  - No additives
  - Low pressure

Combat-related Infections
Care with Surgeon- IIb/III

- Antibiotics
  - Avoid broad spectrum agents
  - Short duration of therapy
  - Same as Echelon I/IIa
  - Topical therapy for burn injuries

Combat-related Infections
Care with Surgeon- IIb/III

- Wound closure
  - Delayed primary closure
  - Early closure of face and dura
  - VAC appears effective but concern about air evacuation



Combat-related Infections
Care with Surgeon- IIb/III

- Stabilization of bony structure
  - External fixation appears effective but some concern about infections

Combat-related Infections

Overall Findings/Recommendation

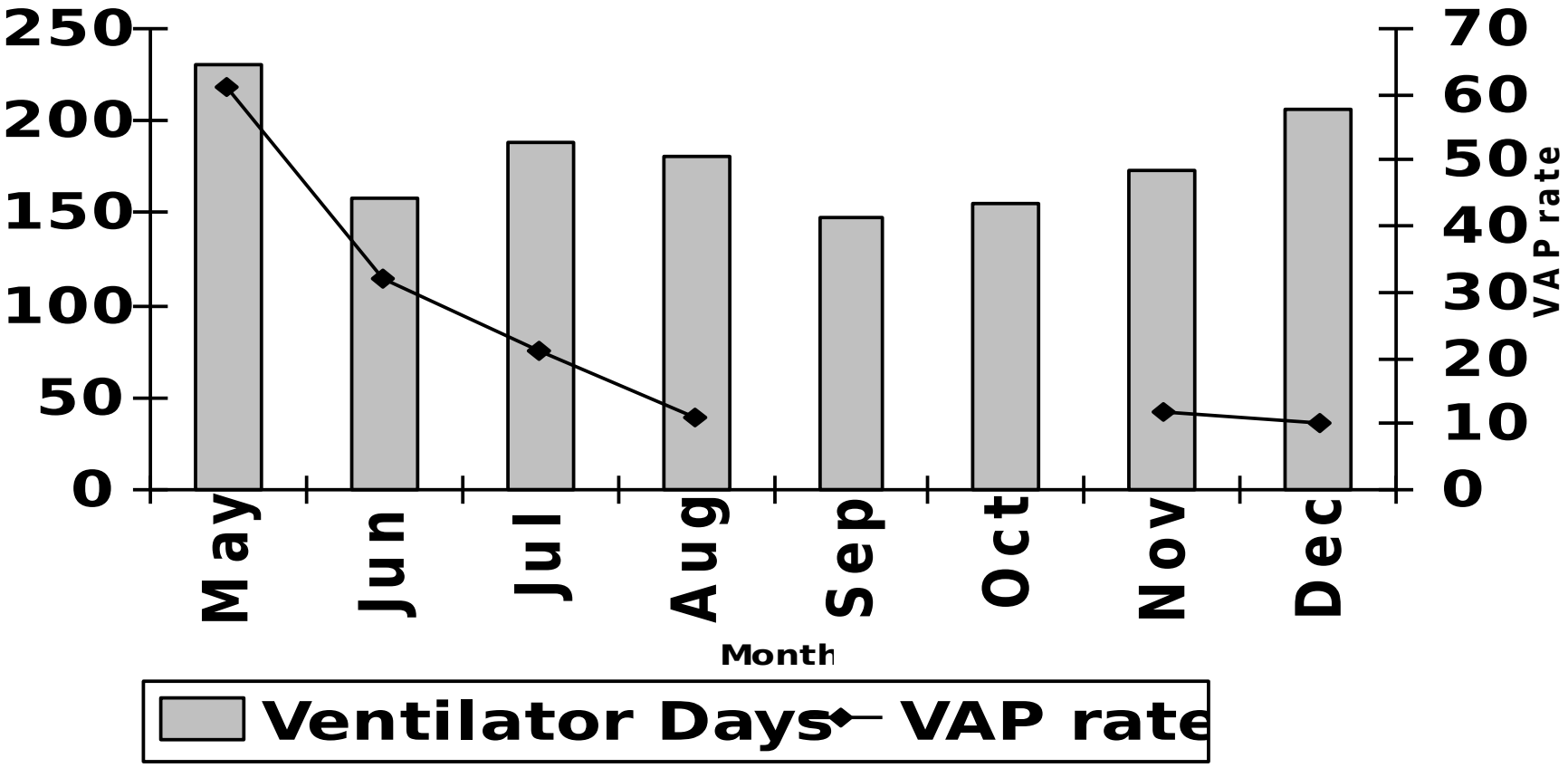
- Resistant bacteria are complicating our war wounded
- Areas of emphasis
  - Decrease use of broad spectrum antibiotics and prolonged courses
  - Standardized treatment protocols
  - Increase emphasis on basic infection control

Combat-related Infections

Overall Findings/Recommendation

- Infectious Disease/Infection Control team in theater
  - Antibiotic control programs
  - Hand hygiene
  - Cohorting

Infection Control
VAP Rates



Chi-square for trend,
p=0.029

Combat-related Infections
Overview

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- Guidelines

Questions?